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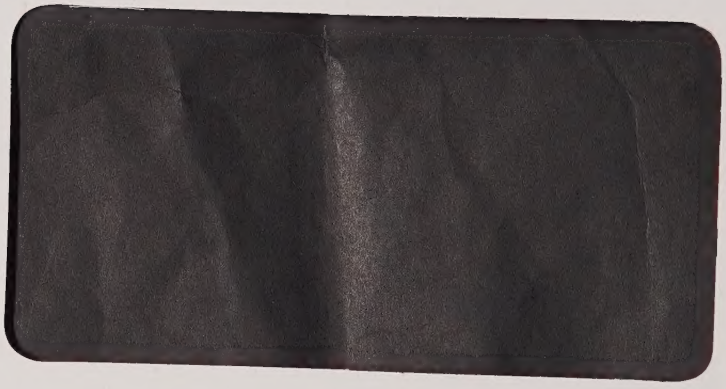

APPLICABLE TO INSTRUMENTS WITH
SERIAL NUMBERS HIGHER THAN 1320

MODEL 301
OSCILLOSCOPE

S.E. LABS

CUSHMAN ELECTRONICS, INC.
830 Stewart Dr. ☐ Sunnyvale, Cal. 94086 ☐ 408—739-6760

5601-0014-2

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Should it appear that the instrument needs to be returned to the factory for service or recalibration, let us know. Shipping instructions will be promptly given to you. There will be no charge for repair on instruments within the one year warranty other than transportation costs after 90 days of ownership. Estimates of charges for non-warranty or any other service will be supplied by the factory upon request before work is begun and such work will be done on an actual cost basis only.

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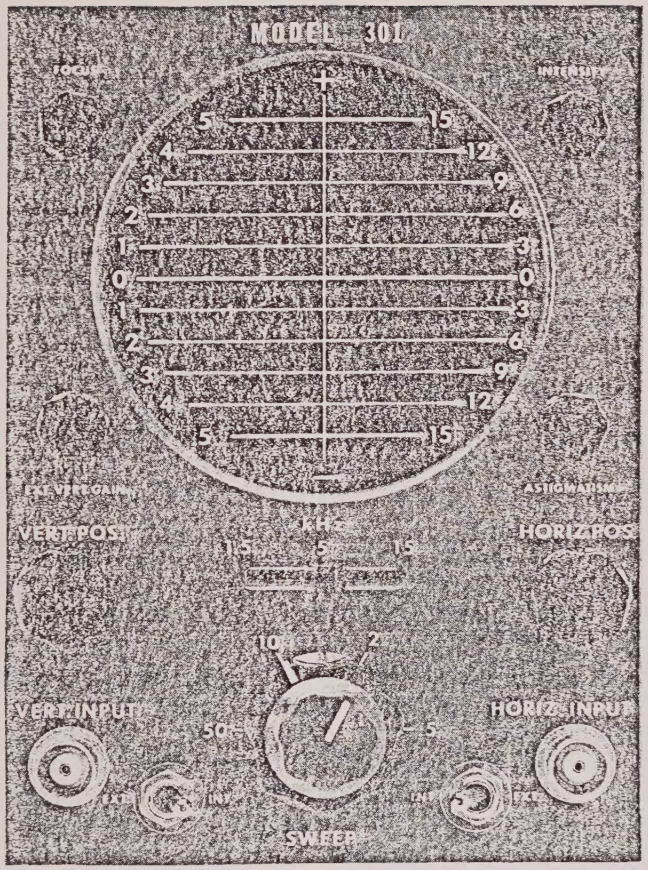

Figure 1.1 Oscilloscope Front Panel

SECTION 1

GENERAL DESCRIPTION

The Model 301 Oscilloscope is designed for use with the Cushman Models CE-3 and CE-7 FM Communications Monitors. The Oscilloscope enables the user to visually examine the exact modulation delivered by the transmitter. Any abnormal conditions such as unbalanced modulation, pulses from the power supply, unusual clipping, and other problems are immediately apparent so that appropriate repairs can be made. The Model 301 has an automatic sync circuit to lock on and precisely display waveforms. Vertical display is calibrated to show deviation on any one of three ranges: ±1.5, ±5, and ±15 kHz.

Front panel switches permit an external vertical signal input while using the internal sweep. External signals may also be connected to the horizontal input. Thus, the oscilloscope can be used independently of the monitoring function for routine testing, trouble shooting, displaying Lissajous patterns, etc.

Table 1.1 Model 301 Specifications

Deviation Accuracy	±5% full scale in three ranges: ±1.5 kHz, 5.0 kHz, 15.0 kHz
External Inputs	Vertical and Horizontal
External Vertical Sensitivity	300 millivolts for full-scale
External Frequency Response (3 db)	30 kHz

SECTION 2
OPERATING INSTRUCTIONS

2.1 General

CAUTION

Prolonged display of a bright spot or trace may burn the face of the CRT. Avoid this condition if possible. Use the CRT at half brightness to prolong the life of the CRT.

High voltages are used in the Model 301 Oscilloscope and the plug-in must not be removed or replaced with the power switch on. It is recommended that the power switch be turned off for 30 seconds before the Model 301 Oscilloscope Plug-In is removed to allow discharge of all high-voltage capacitors.

The Model 301 Oscilloscope Plug-In has the standard oscilloscope front-panel controls, most of which are self-explanatory (See Figure 1-1). A focus control, intensity control, and astigmatism control are provided to ensure a clean trace on the face of the CRT. Vertical and horizontal position controls are provided to position the display and set the display with respect to the zero reference line on the scope graticule when the CE-3 function switch is in the CAL. position.

The lever switch directly below the CRT is a range switch for vertical display of deviation and is directly calibrated in ±1.5, ±5, and ±15 kHz of deviation. The scope circuit is dc-coupled and the displayed deviation will shift up or down if the transmitter under test is off frequency.

Separate external inputs to the vertical or horizontal amplifiers which drive the CRT are provided. Separate toggle switches permit selection of either internal or external signals in conjunction with the external input connectors.

The Model 301 sweep speeds can be adjusted with a sweep-speed switch and vernier control; it is normally unnecessary to adjust the sweep speed to lock the audio waveform being displayed. The Model 301 incorporates an automatic sync control which provides instant lock on any signal exceeding one division in peak-to-peak amplitude. An external-vertical-gain control permits attenuation of signals applied to the external vertical input.

The Model 301 Oscilloscope is removed by turning the large slotted knob on the rear panel of the monitor counterclockwise. When the locking shaft has been disengaged from the plug-in, pushing the knob inward will cause the plug-in connector to separate. The Model 301 can then be easily removed.

2.2 Deviation Measurements

Operation of the Model 301 Oscilloscope with the Model CE-3 or Model CE-7 to measure frequency deviation is described in the Monitor Manual.

2.3 Low-Frequency Phase Comparison

The Model 301 can be used to compare the phase of tone-operated squelch devices (such as the Vibrasender) by using the Oscilloscope in conjunction with the Model 308 Decade Frequency Divider, as follows:

a. Generate an IF/Audio signal in the CE-3 or CE-7 that has a frequency of 10 times, 100 times, or 1000 times that of the signal with which it is to be compared.

b. Set up the correct dividing ratio on the Model 308.

c. Feed the Monitor output through the Model 308 to the HORIZ. INPUT connector of the Model 301.

d. Feed the signal to be compared to the VERT. INPUT connector of the Model 301.

e. Adjust the Monitor output frequency for the slowest moving Lissajous pattern on the Model 301.

SECTION 3
CIRCUIT DESCRIPTION

3.1 General

The circuits of the Model 301 Oscilloscope are on four boards—the Vertical Amplifier board, the Horizontal Amplifier board, the Low-Voltage Power Supply board, and the High-Voltage Power Supply board. The 115-vac supply is fused (2/10 amp S.B.) at the plug-in receptacle J3, in the monitor.

Figure 3-1 is the overall block diagram. The power supply circuits and the usual cathode-ray tube controls (ASTIGMATISM, FOCUS, and INTENSITY) are not shown in the interest of simplicity. The CRT sweep can be either external or internal. The external sweep is applied through the front-panel HORIZ. INPUT BNC connector when the associated switch is in the EXT. position. When the switch is in the INT. position, the sweep comes from the internal sweep generator. The Internal-sweep period is selectable by a four-position switch and a vernier control from less than 0.5 milliseconds to more than 50 milliseconds, and is synchronized with the vertical input. A blanking signal is fed through an amplifier on the High-Voltage Power Supply Board to the cathode of the CRT to blank the return trace. The horizontal position of the CRT trace is adjustable with the HORIZ. POS control, which determines the dc voltage on the horizontal deflection plates.

The input to the CRT vertical deflection plates can be external signal (when the VERT. INPUT switch is in the EXT. position) or it can come from the 2nd I. F. and Discriminator Board of the CE-3 or CE-7 (when the VERT. INPUT switch is in the INT. position). In the INT. position, the oscilloscope displays the modulation deviation of the signal being monitored by the CE-3 or CE-7. In addition, after the oscilloscope trace has been centered vertically by the VERT. POS. control while the Monitor is in the CAL. mode, the Monitor can be switched to the FREQ. -DEV. MEASURE mode and the monitored transmitter's center-frequency error is represented by the displacement of the trace from the CRT center line. Thus, the Model 301 Oscilloscope can be used to indicated frequency error as well as FM deviation.

The vertical signal input is dc-amplified and applied to one of the vertical deflection plates through reversing relay K1. Input to the other vertical deflection plate is an amplifier dc voltage from the VERT. POS. potentiometer. For most settings of the CE-3 frequency selector switches, the LO frequency is 10 MHz lower than the dialed-in frequency. When this is the case, relay K1 is de-energized and its contacts feed the vertical input signal to the vertical deflection plates in such a way as to cause an upward deflection of the CRT trace for an increase in the frequency of the monitored signal. However, when the 1st-digit frequency selector switch is in position 0 or 1 while the 2nd-digit switch is in position 2 or 3, the CE-3 LO frequency is 10 MHz higher than the dialed-in frequency. This would cause the beam to deflect downward for an increase in signal frequency if it were not for the reversing action of relay K1, which is energized in these particular combinations of switch positions. The gain of the vertical amplifiers is controlled by the deviation range switch, which connects different calibrating resistances for the 1.5-, 5-, and 15-kHz ranges into the circuit.

3.2 Vertical Amplifier Board

Figure 5-4 is the schematic diagram of the Vertical Amplifier Board. Transistors Q1 through Q6 comprise a three-stage differential amplifier that drives the vertical deflection plates of the CRT. The base of Q1 is biased to about +3.2 volts, by the Monitor discriminator circuit when the VERT. INPUT switch is in the INT. position, or by voltage divider R3 and R4 when

the switch is in the EXT. position. The bias on the base of Q2 is varied around +3.2 volts by the VERT. POS. potentiometer (R5) to move the CRT trace up or down. The vertical amplifier is designed to have the proper gain to produce full - scale vertical deflection of the CRT when the signal from the Monitor 2nd I. F. and descriminator board corresponds to a deviation of ±15 kHz for the 1.5 - kHz and 5 - kHz deviation ranges, the negative feedback resistors in the emitter circuits of Q5 and Q6 are shunted by appropriate resistances (R30 + R32 for the 1.5 - kHz range and R29 + R31 for the 5 - kHz range) to increase the amplifier gain by the right amount to provide the correct vertical deflection for those ranges. Variable resistors R32 and R31 provide a means for calibrating the two ranges.

Transistor Q7 is the sync amplifier. Its input comes from one of the CRT vertical deflection plates, and its output is fed to the trigger circuit on the Horizontal Amplifier board.

3.3 Horizontal Amplifier Board

On this board are the internal sweep generator for the CRT and the amplifiers to drive the horizontal deflection plates of the CRT from either the internal sweep

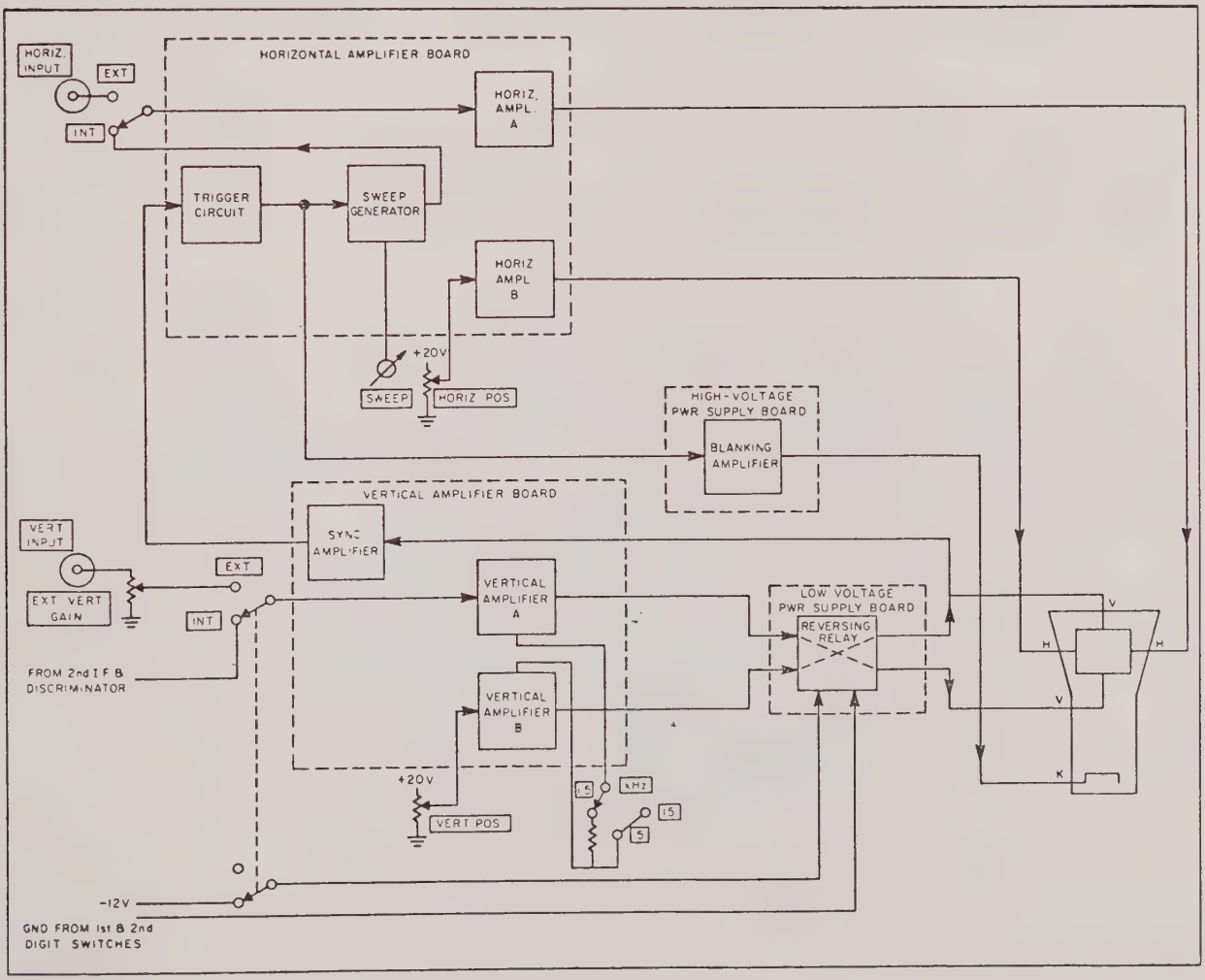

Figure 3.1 Overall Block Diagram

or an external horizontal input. Refer to the Model 301 block diagram (Figure 3-2) and the Model 301 schematic diagram (Figure 5-5).

Assume that the HORIZ. INPUT switch is in the INT. position, the SWEEP switch is in the 10-msec position, and that there is no sync input. With no sync input, the output of Schmitt Trigger Q1/Q2 is essentially ground potential; therefore, resistor R12 is shunted by approximately 10 kilohms (R13 plus R39). This lowered resistance demands more current than the constant-current source (Q6) can supply to keep regenerative switch Q3/Q4 on, hence it turns off. When the regenerative switch turns off, timing capacitor C6 starts charging linearly from the constant current source. When C6 charges to the threshold level of the regenerative switch, the switch closes and dishcarges C6. After C6 discharges, the shunt across R12 again causes the regenerative switch to turn off, and C6 recharges. Thus, a sawtooth waveform is generated at the top plate (in the block diagram) of C6. This sweep waveform is fed through emitter follower Q7 and one half of a differential amplifier (Q9/Q11) to one of the horizontal deflection plates. The other horizontal deflection plate is fed by the other half of the differential amplifier (Q10/Q12), the input of which is a dc

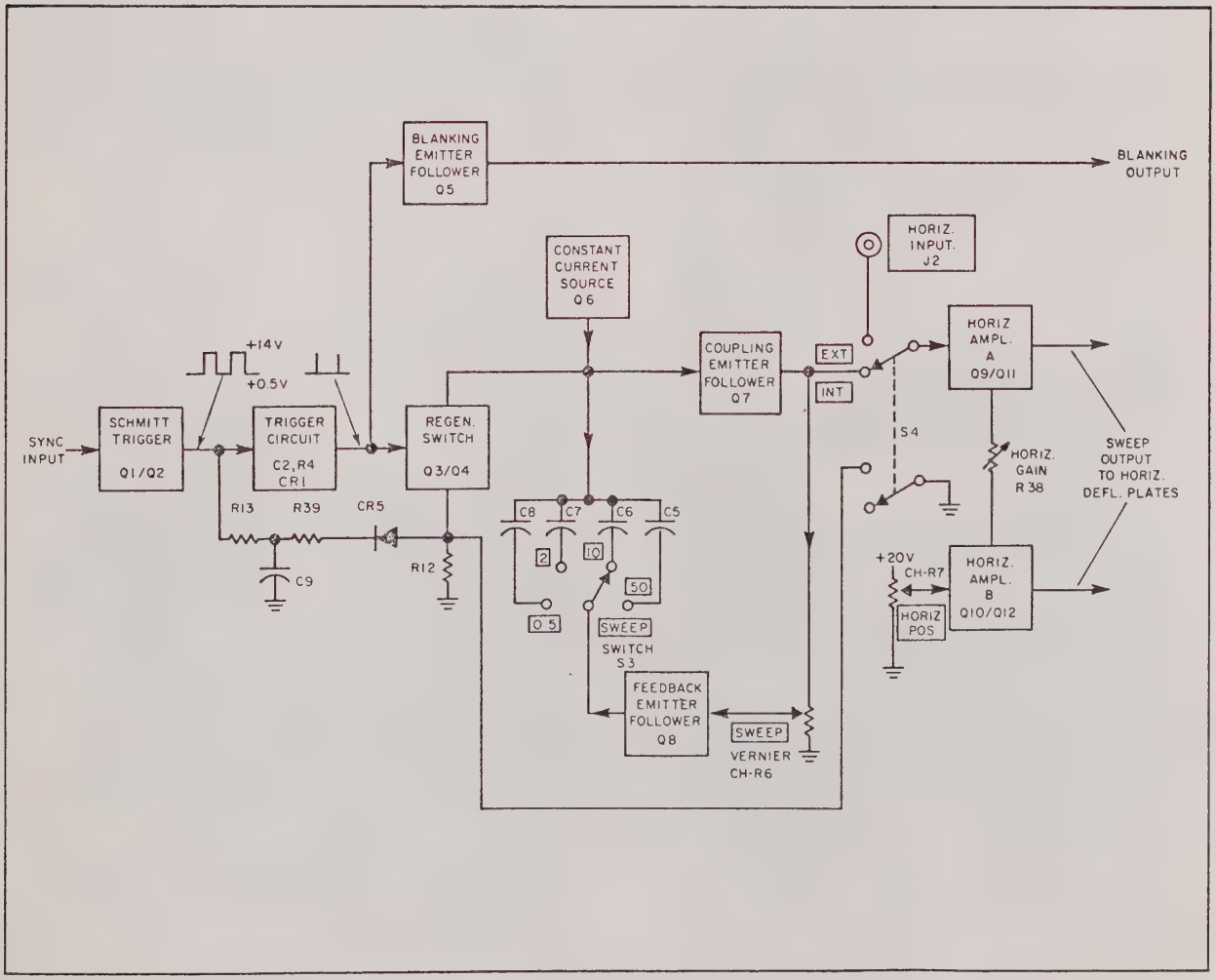

Figure 3.2 Horizontal Amplifier Board, Block Diagram

voltage adjustable by HORIZ. POS. potentiometer R7.

The bottom plate of timing capacitor C6 is not returned to ground as is conventional, but instead, is fed a portion of the potential from the top plate of the capacitor through emitter followers Q7 and Q8. This changes the effective capacitance of C6 and therefore the timing period. The amount by which the effective capacitance is changed is controlled by the SWEEP vernier potentiometer, R6. Thus, the sweep period is determined not only by the timing capacitor selected by the SWEEP switch, but also by the setting of the SWEEP vernier control (the red knob concentric with the black SWEEP switch).

Now assume that a sync signal is being received from the vertical-deflection input of the CRT. This sync signal is converted to a rectangular waveshape by Schmitt Trigger Q1/Q2, and is further converted to positive trigger pulses by the circuit consisting of C2, R9, and CR1. The output of the Schmitt Trigger also charges C9 to a positive voltage; this voltage backbiases CRT, thus removing shunt resistors R13 and R39 from the regenerative switch circuit. The regenerative switch can now be turned off only by a positive pulse from the trigger circuit. The regenerative switch stays off until timing capacitor C6 charges to the threshold level of the switch. When this happens, C6 discharges, and cannot start charging again to produce a new sweep until a trigger pulse is received from the sync circuit. Thus, the sweep is synchronized with the vertical input.

When the HORIZ. INPUT switch is in the EXT. position, the junction of R12 and CR5 in the regenerative switch circuit is grounded to stop generation of the internal sawtooth. The gain of the differential amplifier is adjustable by potentiometer, R38, which varies the amount of negative feedback in the output stage.

3.4 High-Voltage Power Supply Board

This board furnished -1200 volts for the CRT. As shown in the schematic diagram, Figure 5-2, the 920 volts across the high-voltage secondary of transformer T1 is applied to the voltage-doubler rectifier consisting of C1, CR1, CR2, and C2. The approximately -2100 volts across C2 is reduced by the regulator circuit; R1, R2, R3, and CR3–CR8 to a regulated -1200 volts. The -1200 volts output is applied through R9 100k ohm, to the grid of the CRT, and also across the voltage-divider chain consisting of INTENSITY control, CH-R2, R11, FOCUS control, CH-R1, R12, and R13. The potential on the cathode of the CRT is set by the INTENSITY control, which determines the negative bias on the grid (pin 2) with respect to the cathode; in addition, during retrace a negative pulse from the horizontal amplifier is inverted by Q1 and applied through capacitor C4 to the cathode of the CRT, cutting off the beam.

3.5 Low-Voltage Power Supply Board

This board (Figure 5-3) furnishes 240 volts to the horizontal amplifier on the Horizontal Amplifier board, and to the ASTIGMATISM potentiometer and blanking amplifier on the High-Voltage Power Supply board. An ac voltage of 245 volts rms from one of the secondaries of T1 on the High-Voltage Power Supply board is applied to bridge rectifier CR1 through CR4. The positive 320-volt output of the bridge rectifier is fed through the emitter-follower regulator, consisting of Q1, R2, CR5, and CR6, to the board connector.

Resistor R3 and R5, together with R4, are the collector load resistors of vertical amplifiers Q5 and Q6 on the Vertical Amplifier board. Potentiometer R4 permits changing the values of the load resistances slightly to compensate for any difference in gain of the two transistors and to adjust the electrical displacement of the beam to mid-scale. The function of relay K1 is explained in Section 3.1.

SECTION 4
MAINTENANCE

4.1 Calibration Adjustments

There are six internal adjustments in the Model 301 Oscilloscope. Controls for these adjustments are located as shown in Figures 4-1 and 4-2. The adjustments (except the horizontal gain adjustment) are made with the Model 301 plugged into the CE-3 or CE-7 Monitor and operating. The controls shown in Figure 4-1 can be reached by removing the left-hand CE-3 or CE-7 cover, as described in the maintenance section of the Monitor Manual. The only test equipment required is an unmodulated transmitter operating on any frequency covered by the Monitor. Unless otherwise stated, the controls mentioned in the following procedures are on the Model 301 Oscilloscope.

4.1.1 Vertical Amplifier Balance

Before making any adjustments of the vertical deviation ranges, the vertical amplifier balance should be checked as follows:

a. Place the Monitor function switch in the CAL. position.

b. Set the front-panel VERT. POS. control to mid-position.

c. Set the front-panel range switch to the ±15-kHz position and note the position of the trace on the CRT.

d. Switch to ±1.5-kHz range and adjust the position of the trace to the same point noted above, using the vertical amplifier balance control (see Figure 4-1).

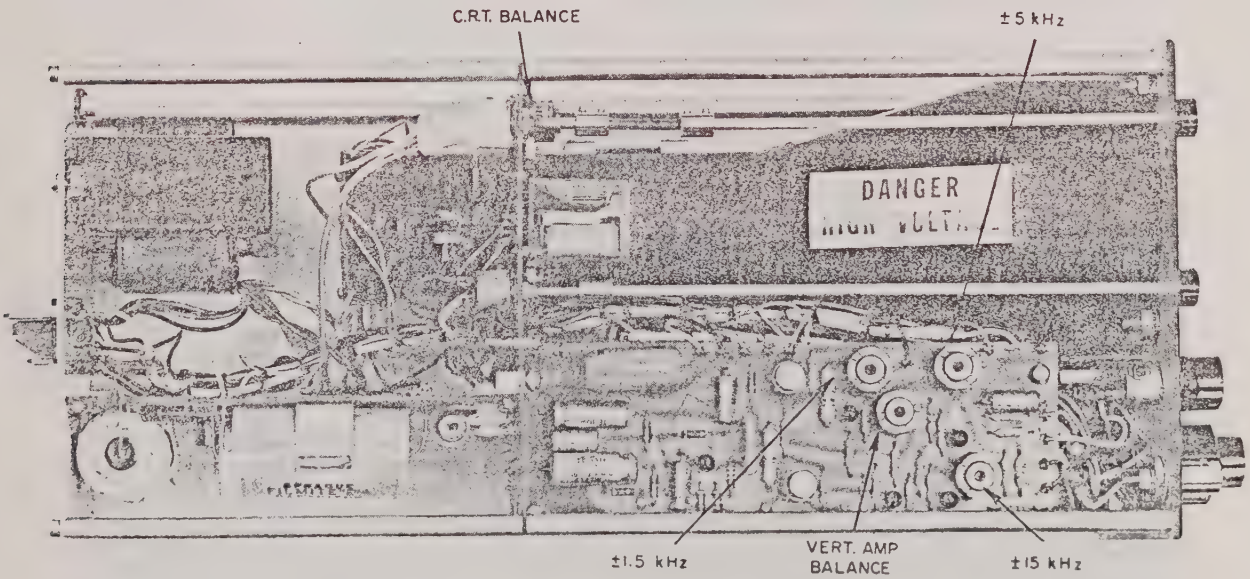

Figure 4.1 Model 301 Oscilloscope, Left-Side View of Interior

4.1.2 Vertical Gain

a. "Dial-in" the frequency of the transmitter being used for the test.

b. In the CAL. position of the Monitor function switch, adjust the CAL. control for a zero or mid-scale reading on the frequency meter.

c. Set the front-panel deviation range switch to ±1.5 kHz and adjust the VERT. POS. control so the trace is on the "0" reference line.

d. Set the Monitor function switch to the FREQ. -DEV. MEAS. position. Key the transmitter and adjust it "right on frequency" on the ±1.5-kHz FREQUENCY error meter range.

e. With the deviation range switch set to ±15 kHz, offset the "dialed-in" frequency 15 kHz high and low from the FCC assigned frequency. The scope trace should shift up and down by 15 kHz. If adjustment is required, use the ±15-kHz potentiometer; then recheck the transmitter frequency.

f. Repeat step "e" on the ±5-kHz deviation range by offsetting the "dialed-in" frequency by 5 kHz. Adjust the ±5-kHz potentiometer if necessary.

g. Repeat step "e" on the ±1.5-kHz deviation range by offsetting the "dialed-in" frequency by 1.0 kHz. Adjust the ±1.5-kHz potentiometer if necessary.

h. Recheck the vertical amplifier balance adjustment by repeating steps "a" through "d" of section 4.1.1.

4.1.3 CRT Balance

If the trace is not on the zero reference line after adjusting the vertical amplifier balance control, adjust the CRT balance control until the trace is on the zero reference line (See Figure 4-1 for location of the CRT balance control). This control centers the range of the front-panel VERT. POS. control

4.1.4 Horizontal Gain

An internal gain control on the horizontal amplifier permits adjustment of the sweep length. This control is located on the right side of the Oscilloscope plug-in and cannot

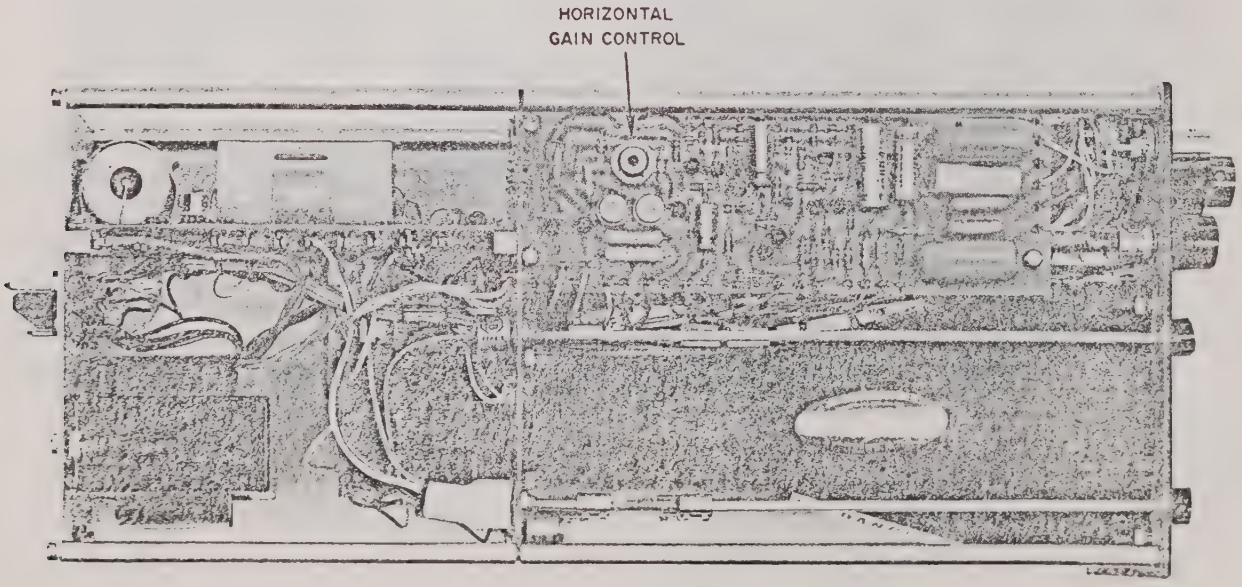

Figure 4.2 Model 301 Oscilloscope, Right-Side View of Interior

be reached with the scope plugged into the Monitor.

CAUTION

Turn the ac power to the Monitor OFF before removing the Oscilloscope plug-in and while replacing the plug-in.

If the sweep length is short, remove the Oscilloscope from the Monitor and adjust the horizontal gain potentiometer (See Figure 4-2) in the counterclockwise direction. The sweep length is not critical, but should be adjusted to provide a full sweep of the trace when it is on the zero reference line.

4.2 Typical Voltages and Waveforms

Tables 4-1 through 4-6 give typical data for the four Oscilloscope boards and the CRT. Test conditions are as follows unless otherwise stated:

Line Voltage	115 vac
Control Settings:	
FOCUS	Mid-range or optimum
INTENSITY	Mid-range
EXT. VERT. GAIN	Minimum
ASTIGMATISM	Mid-range or optimum
VERT. POS.	Mid-range
HORIZ. POS.	Mid-range
Deviation Range	±15 kHz
SWEEP Range	50 msec
SWEEP Vernier	Fully ccw.

Table 4.1 High-Voltage Supply Board, Voltage Chart

(No vertical input; INTENSITY control max clockwise)

	HORIZ. INPUT Switch in INT. Position	HORIZ. INPUT Switch in EXT. Position
Transformer HV Sec	920 vac	920 vac
CR1 Cathode	-1125 vdc	-1125 vdc
CR1 Anode	-2180 vdc	-2180 vdc
CR3 Anode	-1200 vdc	-1200 vdc
CR8 Anode	-0.3 vdc (approx.)	-0.32 vdc (approx.)
Q1 Base (dc)	9.6v	--
(ac)	0.8v	
	40 vdc	9.5 vdc
Q1 Collector (dc)	150v	--
(ac)	16v	

NOTE: All readings should be taken with VTVM or 1 megohm/voltmeter.

Table 4.2 Low-Voltage Power Supply Board, Voltage Chart

Input to Bridge Rectifier	245 vac
C1	300 ± 5 vdc
	0.7 vac
Q1 Base	240 ± 10 vdc
Test Point TP1	240 ± 10 vdc

Table 4.3 CRT Voltage Chart

Filament;	
Pin 12	-1200 vdc
Pin 1	-1200 vdc
Grid; Pin 2	-1200 vdc
Cathode; Pin 3	-1160 vdc
Focus; Pin 4	-840 vdc
Vertical Plates;	
Pin 6	+125 vdc
Pin 7	+125 vdc
Astigmatism; Pin 8	+125 vdc
Horizontal Plates;	
Pin 9	+125 vdc
Pin 10	+125 vdc

Table 4.4 Vertical Amplifier Board, Voltage Chart

Q1 Base	3.2 vdc 0.90v p-p ac
Q1 Collector	7.4 vdc 1.5v p-p ac
Q2 Base	3.2 vdc 0.0v p-p ac
Q2 Collector	7.4 vdc 0.87v p-p ac
Common #1	-3.6 vdc 0.0v p-p ac (approx)
Q3 Emitter	8.4 vdc
Q4 Emitter	8.4 vdc
Common #2	10.7 vdc 0.0v p-p ac (approx)
Q5 Base	-1.2 vdc 5.2v p-p ac
Q5 Collector	125.0 vdc 80.0v p-p ac
Q6 Base	-1.2 vdc 4.2v p-p ac
Q6 Collector	125.0 vdc 77.0v p-p ac
Common #3	-8.8 vdc 0.0v p-p ac (approx)
Q7 Base	1.4 vdc 1.0v p-p (clipped) ac
Q7 Collector	8.0 vdc 12.0v p-p (clipped) ac

NOTE: With 0.32-vac, 1-kHz, 3.2-vdc input; 15-kHz range. Above readings depend on settings of all potentiometers.

Table 4.5 Horizontal Amplifier Board, Voltage Chart

	No Vertical Signal HORIZ. INPUT Switch in. EXT. Position	Vertical Signal; HORIZ. INPUT Switch in INT. Position; SWEEP Switch at 10 msec SWEEP Vernier Max. CCW
Q1 Base	0.0 vdc	-4.9 vdc
Q1 Collector	11.7 vdc	6.8 vdc
Q2 Base	1.0 vdc	0.60 vdc
Q2 Collector	0.50 vdc	6.5 vdc
Q3 Base	10.6 vdc	9.6 vdc
Q3 Collector	0.0 vdc	0.16 vdc
C9	0.40 vdc	6.0 vdc
Q6 Emitter	14.2 vdc	14.2 vdc
Q6 Collector	11.8 vdc	7.0 vdc
Q8 Emitter	0.95 vdc	0.70 vdc
Q5 Emitter	10.0 vdc	9.2 vdc
Q9 Base	0.5 vdc	0.5 vdc
Q9 Collector	-4.0 vdc	-4.0 vdc
Q10 Base	0.7 vdc	0.7 vdc
Q10 Collector	-4.0 vdc	-4.0 vdc
Common #1	+3.7 vdc	+3.7 vdc
Q11 Collector	128.0 vdc	125.0 vdc
Q12 Collector	134.0 vdc	135.0 vdc
Common #2	-7.8 vdc	-7.8 vdc

Table 4.6 Horizontal Amplifier Board Waveforms

Q1		Q2		Q3		Q6		Q8	Q5	Q9		Q10		COMMON #1	Q11	Q12	COMMON #2
B	C	B	C	B	C	E	C	E	E	B	C	B	C		C	C	
+0.8 -11	+11 +0.4	+1 0.1	+14 +.5	10.2 1.4	+.8 0	--	11.2 2.7	0.9 -8	9.4 0.8	1.0 0.2	-3.6 -4.8	≈0	-3.7 -4.4	≈0	+220 55	200 40	≈0

Numbers on waveforms indicate voltages with respect to ground.
B = Base; C = Collector; E = Emitter.

SECTION 5
SCHEMATICS, PARTS LISTS, AND PARTS PICTORIALS

5.1 Introduction

Section 5 contains parts pictorials, parts lists, schematic diagrams, and a wiring diagram for the Model 301 Oscilloscope. Table 5-1 lists the reference designators and abbreviations used.

5.2 Schematics, Parts Lists, and Parts Pictorials

Paragraph 5.2.1 on the following pages provide a wiring diagram, parts list, and parts pictorials for the front panel and main chassis of the Model 301. Paragraphs 5.2.2 through 5.2.5 provide schematics, parts lists, and parts pictorials for the four printed circuit boards of the Model 301.

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Table 5-1. Reference Designators and Abbreviations

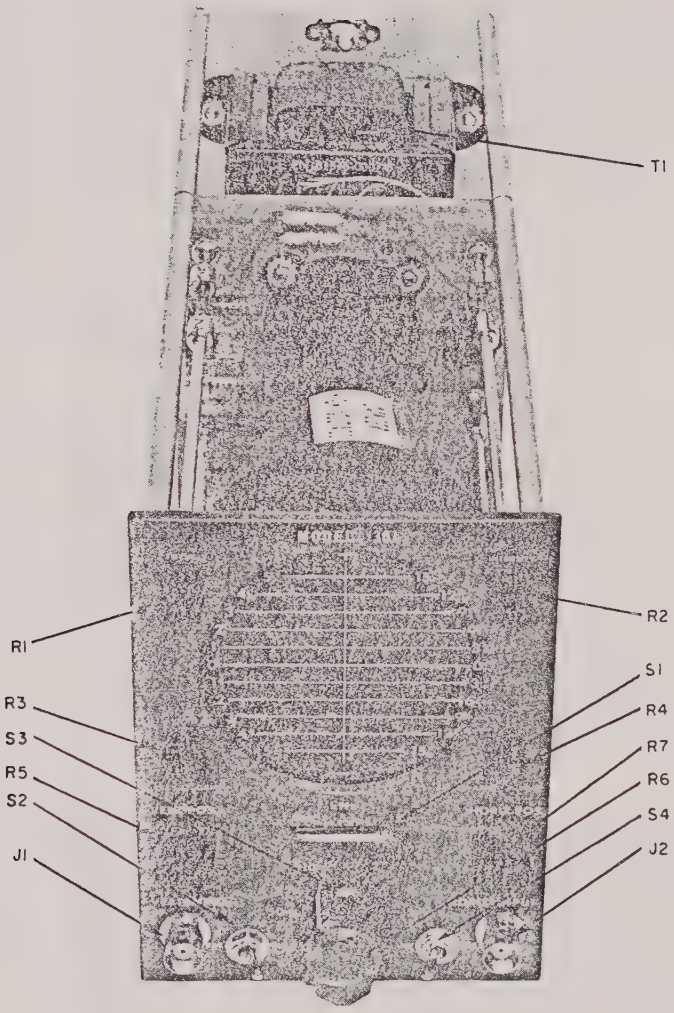
REFERENCE DESIGNATORS

A	assembly
BM	balanced mixer
B	board
C	capacitor
CH	chassis
Y	crystal
DS	device, indicating
CR	diode
V	electron tube
E	electronic part, misc.
FL	filter
FP	front panel
F	fuse
HR	heater
Hz	hertz
L	inductor, RF choke
J	jack
M	meter
P	plug
RP	rear panel
K	relay
R	resistor
SCR	silicon controlled rectifier
LS	speaker
S	switch
TB	terminal board
TP	test point
TF	thermal fuse
RT	thermistor
S	thermostat
T	transformer
Q	transistor
WT	wiring tiepoint

ABBREVIATIONS

AC	alternating current
ADJ	adjust
AFC	automatic frequency control
AMP	amperes
AMPL	amplifier
ANT.	antenna
AUX	auxiliary
BP	bandpass
C	centigrade
CAL	calibrate
CCW	counterclockwise
CER	ceramic
COAX.	coaxial
COEF	coefficient
COM	common
COMP	composition
CONN	connector
CRT	cathode-ray tube
CW	clockwise
CW	continuous wave
DB	decibel
DC	direct current
Deg	degree
DEV	deviation
ELECT.	electrolytic
ENCAP	encapsulated
EXT	external
F	fahrenheit
F	farad
FM	frequency modulation
FREQ	frequency
Ge	germanium
GRD	ground
H	henry
Harm	harmonic
Hz	hertz
IC	integrated circuit
IF	intermediate frequency
INCD	incandescent
IN.	inch
INT	internal
K	kilo (10^3)
LIN	linear
LO	local oscillator
LOG.	logarithmic
LP	lowpass
M	milli (10^{-3})
MEG	mega (10^6)
MFR	manufacture
MINAT	miniature
MY	mylar
N	nano (10^{-9})
P	peak
PC	printed circuit
pF	picofarad (10^{-12})
PIV	peak inverse voltage
POS	position(s)
POT.	potentiometer
PP	peak-to-peak
P/O	part of
RECT	rectifier
REPL	replace
RF	radio frequency
SB	slo-blo
SEC	second
Semicond	semiconductor
Si	silicon
Ta	tantalum
TGL	toggle
TOL	tolerance
TRIM	trimmer
TYP	typical
μ	micro (10^6)
UHF	ultra high frequency
V	volt
VAR	variable
VDCW	dc working volts
VERT.	vertical
VHF	very high frequency
W	watt
WW	wire-wound
W/	with
W/O	without

5.2.1 Front Panel and Chassis



5.2.1 FRONT PANEL & CHASSIS COMPONENTS

CKT. REF.	DESCRIPTION	C/E STOCK NO.	MFR.
	RESISTORS		
R1	Pot., comp, 1 megohm, 1/2W	1203-0039	Allen-Bradley
R2	Pot., comp, 500k ohm, 1/2W	1203-0038	Allen-Bradley
R3	Pot., comp, 100k ohm, 1/2W	1203-0036	Allen-Bradley
R4	Pot., comp, 500k ohm, 1/2W	1203-0038	Allen-Bradley
R5	Pot., comp, 100 ohm, 1/2W	1203-0037	Allen-Bradley
R6	Pot., comp, 10k ohm, 1/2W	1851-0024 P/O	CTS
R7	Pot., comp, 1k ohm, 1/2W	1203-0035	Allen-Bradley
	SWITCHES		
S1	Lever, 1P3 pos	1851-0016	Centralab
S2	Toggle, 3P2 pos	1850-0007	Alco
S3	Rotary, 1P4 pos	1851-0024 P/O	CTS
S4	Toggle, 3P2 pos	1850-0007	Alco
	JACKS		
J1	Connector	2536-0003	Kings
J2	Connector	2536-0003	Kings
J3	Tube socket, 12 pin	2605-0011	Cinch
	PLUGS		
P1	Connector, 24 pin, male	2535-0019	Amphenol
	TRANSFORMERS		
T1	Power Transformer	1575-0007	Basler
	KNOBS		
	Knob, FOCUS 7/16 in dia Blk	2780-0019	Kurz-Kasch
	Knob, INTENSITY 7/16 in dia Blk	2780-0019	Kurz-Kasch
	Knob, EXT. VERT. GAIN 7/16 in dia Blk	2780-0019	Kurz-Kasch
	Knob, ASTIGMATISM 7/16 in dia Blk	2780-0019	Kurz-Kasch
	Knob, VERT. POS. 5/8 in dia Blk	2780-0017	Kurz-Kasch
	Knob, HOR. POS. 5/8 in dia Blk	2780-0017	Kurz-Kasch
	Knob, SWEEP, inner 3/4 in dia Red	2780-0009	Kurz-Kasch
	Knob, SWEEP, outer 1 in dia Blk	2780-0007	Kurz-Kasch
	TUBES		
	CRT, 3P1A, 3-inch flat faceplate	1270-0019	RCA
	MISCELLANEOUS		
	Graticule, CRT	4941-0004	Cushman

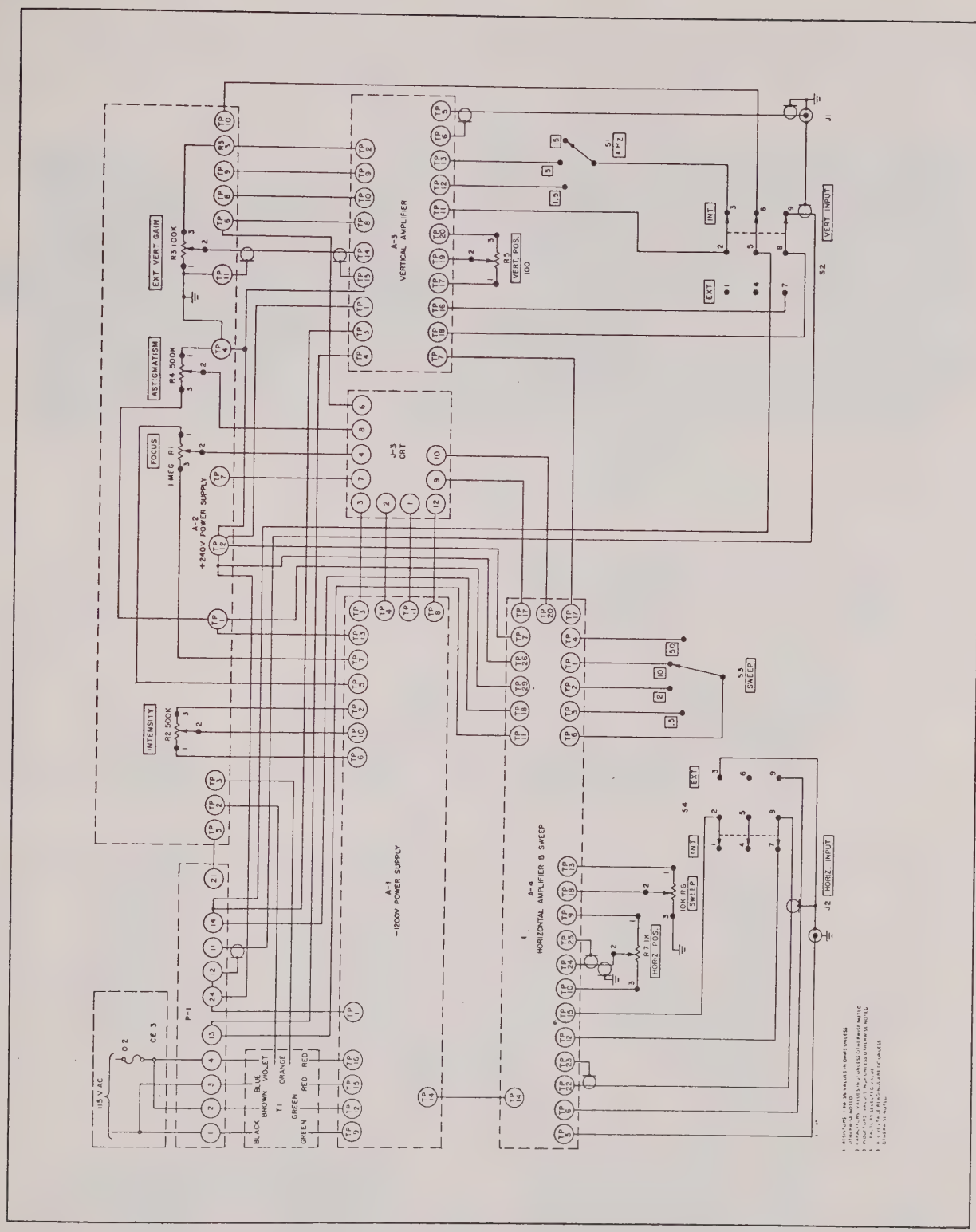
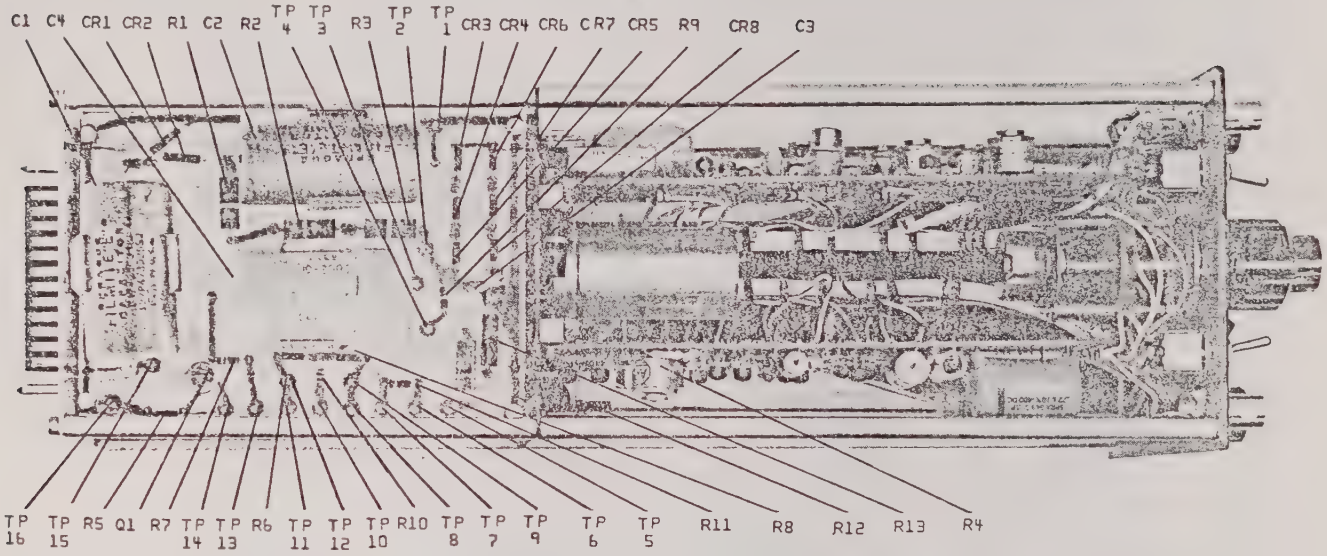


Figure 5.1 Model 301 Oscilloscope, Wiring Diagram

5.2.2 High-Voltage Supply Board


C1 C4 CR1 CR2 R1 C2 R2 TP 4 TP 3 R3 TP 2 TP 1 CR3 CR4 CR6 CR7 CR5 R9 CR8 C3
TP 16 TP 15 R5 Q1 R7 TP 14 TP 13 R6 TP 11 TP 12 TP 10 R10 TP 8 TP 7 TP 9 TP 6 TP 5 R11 R8 R12 R13 R4

5.2.2 HIGH VOLTAGE POWER SUPPLY BOARD 0074

CKT. REF.	DESCRIPTION	C/E STOCK NO.	MFR.
	CAPACITORS		
C1	Metalized Film, 0.047 μF ±10%, 2500V	1008-0030	Sprague
C2	Metalized Film, 0.047 μF ±10%, 2500V	1008-0030	Sprague
C3	Cer, 47 pF ±20%, 3000V	1005-0045	Centralab
C4	Mylar, 0.47 μF ±20%, 1400V	1008-0044	TRW
	DIODES		
CR1	Si, VB-40	1281-0029	Varo
CR2	Si, VB-40	1281-0029	Varo
CR3	Si, Zener, 1N992B	1281-0032	Fairchild
CR4	Si, Zener, 1N992B	1281-0032	Fairchild
CR5	Si, Zener, 1N992B	1281-0032	Fairchild
CR6	Si, Zener, 1N992B	1281-0032	Fairchild
CR7	Si, Zener, 1N992B	1281-0032	Fairchild
CR8	Si, Zener, 1N992B	1281-0032	Fairchild
	TRANSISTORS		
Q1	Si, 2N3440	1271-0004	RCA
	RESISTORS		
R1	Comp, 560k ohm ±5%, 1W	1068-5645	Allen-Bradley
R2	Comp, 560k ohm ±5%, 1W	1068-5645	Allen-Bradley
R3	Comp, 560k ohm ±5%, 1W	1068-5645	Allen-Bradley
R4	Comp, 1k ohm ±5%, 1/4W	1066-1025	Allen-Bradley
R5	Comp, 5.6k ohm ±5%, 1/4W	1066-5625	Allen-Bradley

CKT. REF.	DESCRIPTION	C/E STOCK NO.	MFR.
R6	Comp, 2M ohm ±5%, 1/4W	1066-2055	Allen-Bradley
R7	Comp, 150k ohm ±5%, 1/4W	1066-1545	Allen-Bradley
R8	Comp, 2M ohm ±5%, 1/4W	1066-2055	Allen-Bradley
R9	Comp, 100k ohm ±5%, 1/4W	1066-1045	Allen-Bradley
R10	Comp, 330k ohm ±5%, 1/4W	1066-3345	Allen-Bradley
R11	Comp, 1.5M ohm ±5%, 1/4W	1066-1555	Allen-Bradley
R12	Comp, 2.2M ohm ±5%, 1W	1068-2255	Allen-Bradley
R13	Comp, 2.7M ohm ±5%, 1W	1068-2755	Allen-Bradley

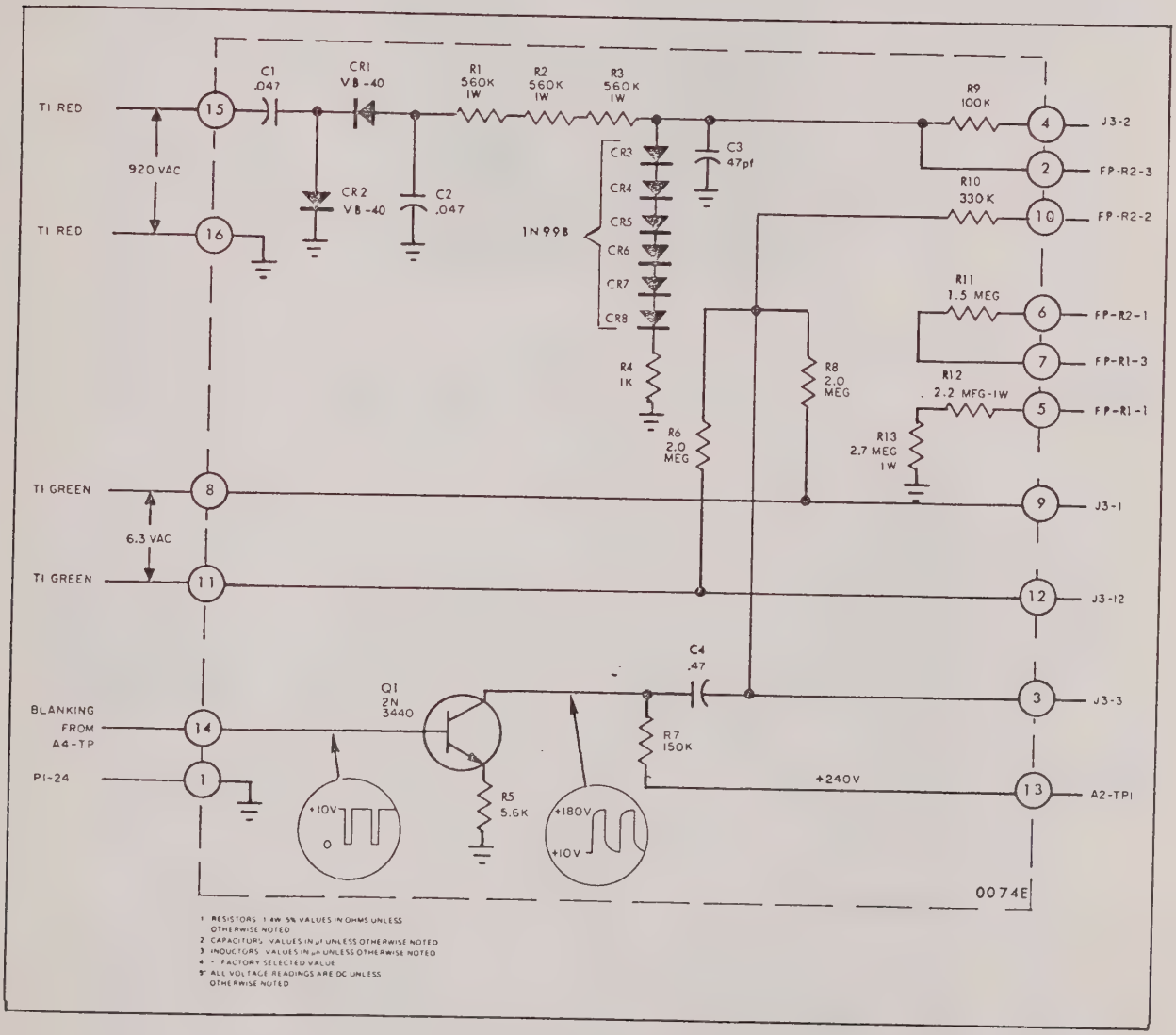
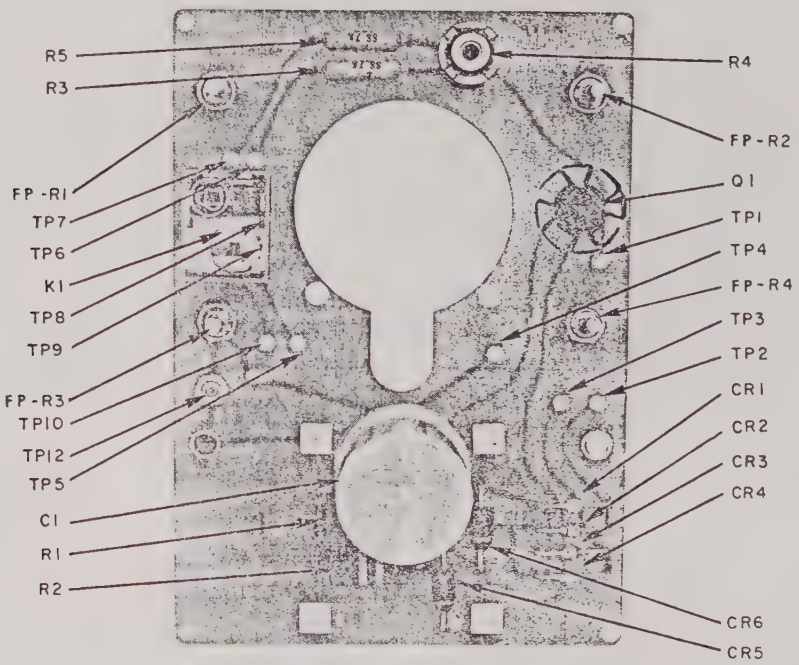


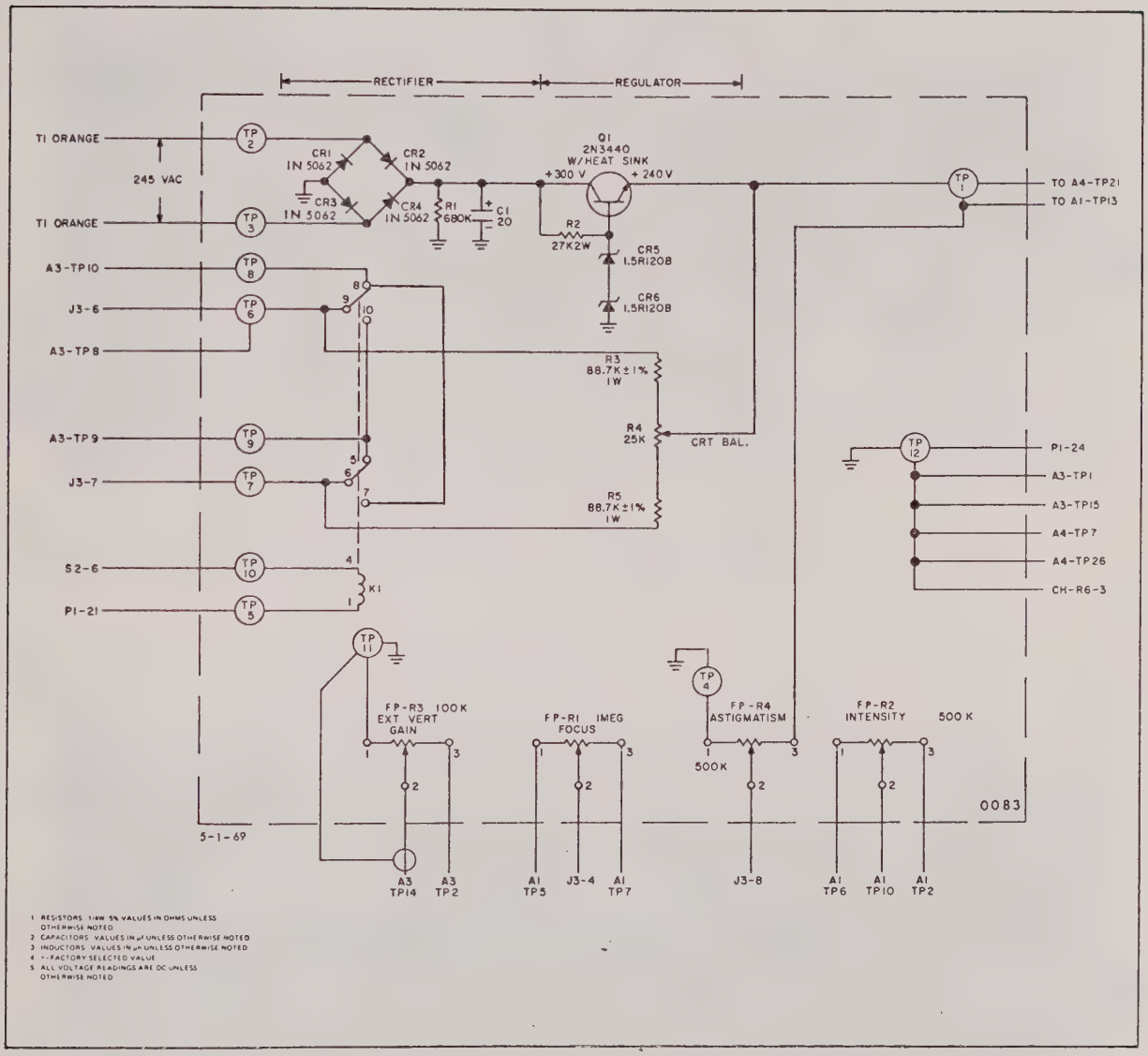
Figure 5.2 High Voltage Power Supply, Schematic Diagram

5.2.3 Low Voltage Power Supply



5.2.3 LOW VOLTAGE POWER SUPPLY BOARD 0083

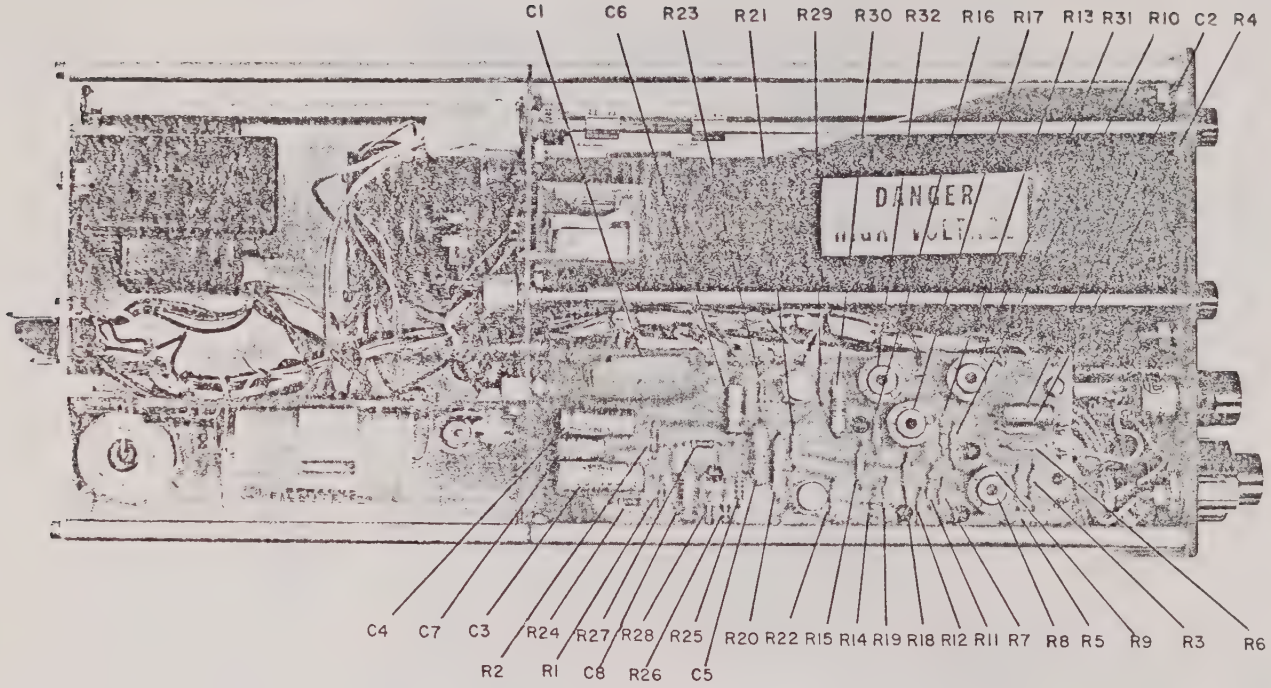
CKT. REF.	DESCRIPTION	C/E STOCK NO.	MFR.
	CAPACITORS		
C1	Electro, 20 μF, 450V	1010-0004	Sprague
	DIODES		
CR1	Si, 1N5062	1281-0030	General Electric
CR2	Si, 1N5062	1281-0030	General Electric
CR3	Si, 1N5062	1281-0030	General Electric
CR4	Si, 1N5062	1281-0030	General Electric
CR5	Si, Zener, 120V, 1.5R120B	1281-0022	Solitron
CR6	Si, Zener, 120V, 1.5R120B	1281-0022	Solitron
	RELAYS		
K1	12 VDC, DPDT	1313-0002	Parelco
	TRANSISTORS		
Q1	Si, NPN, 2N3440	1271-0004	RCA
	RESISTORS		
R1	Comp, 680k ohm ±5%, 1/4W	1066-6845	Allen-Bradley
R2	Comp, 27k ohm ±5%, 2W	1069-2735	Allen-Bradley
R3	M Film, 88.7k ohm ±1%, 1W	1076-0008	Electra
R4	Pot., comp, 25k ohm, 1/2W	1200-0014	Allen-Bradley
R5	M Film, 88.7k ohm ±1%, 1W	1076-0008	Electra

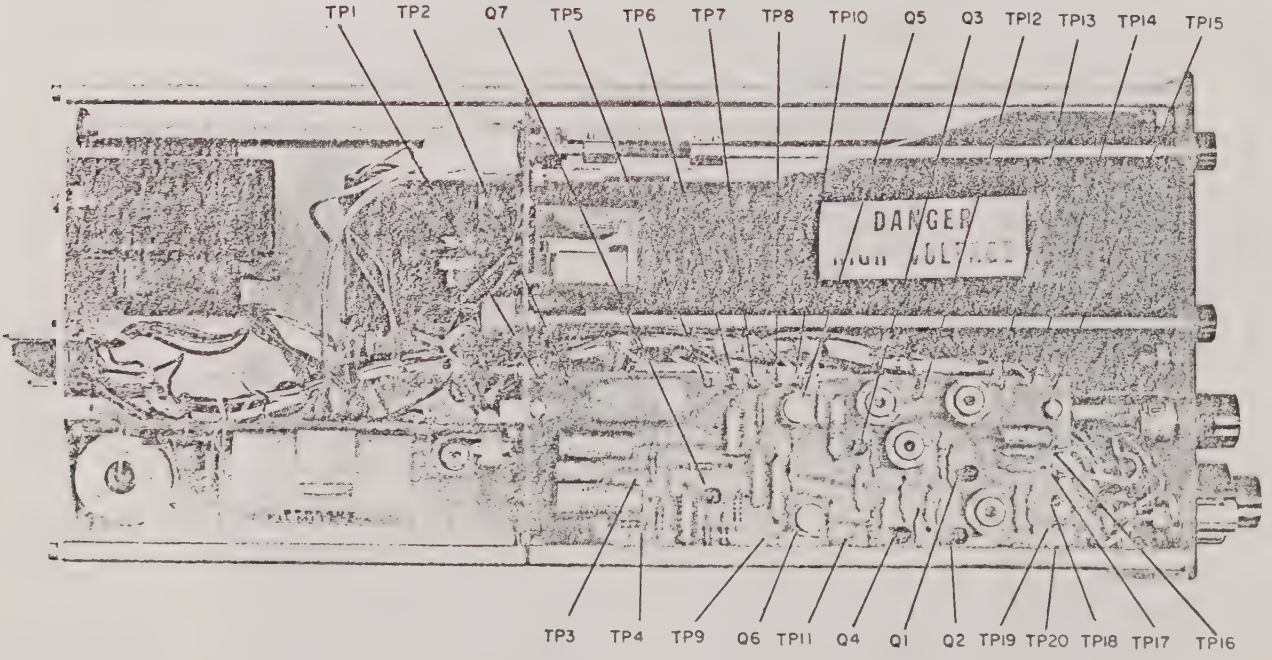


1 RESISTORS 1/4W 5% VALUES IN OHMS UNLESS OTHERWISE NOTED
2 CAPACITORS VALUES IN μf UNLESS OTHERWISE NOTED
3 INDUCTORS VALUES IN μh UNLESS OTHERWISE NOTED
4 *-FACTORY SELECTED VALUE
5 ALL VOLTAGE READINGS ARE DC UNLESS OTHERWISE NOTED

Figure 5.3 Low Voltage Power Supply, Schematic Diagram

5.2.4 Vertical Amplifier Board





5.2.4 VERTICAL AMPLIFIER BOARD 0071D

CKT. REF.	DESCRIPTION	C/E STOCK NO.	MFR.
	CAPACITORS		
C1	Poly, 0.22 μF ±10%, 400V	1008-0042	Sprague
C2	Electro, 1 μF, 25V	1013-0004	Sprague
C3	Electro, 100 μF, 25V	1013-0003	Sprague
C4	Electro, 100 μF, 12V	1013-0011	Sprague
C5	Poly, 0.01 μF ±10%, 200V	1008-0043	Sprague
C6	Electro, 1 μF, 25V	1013-0004	Sprague
C7	Electro, 1 μF, 25V	1013-0004	Sprague
C8	Electro, 15 μF, 12V	1013-0015	Sprague
	TRANSISTORS		
Q1	Si, NPN, 2N3565	1272-0017	Fairchild
Q2	Si, NPN, 2N3565	1272-0017	Fairchild
Q3	Si, PNP, 2N4249	1272-0024	Fairchild
Q4	Si, PNP, 2N4249	1272-0024	Fairchild
Q5	Si, NPN, 2N3440	1271-0004	RCA
Q6	Si, NPN, 2N3440	1271-0004	RCA
Q7	Si, NPN, 2N3565	1272-0017	Fairchild
	RESISTORS		
R1	Comp, 100 ohm ±5%, 1/4W	1066-1015	Allen-Bradley
R2	Comp, 100 ohm ±5%, 1/4W	1066-1015	Allen-Bradley
R3	M Film, 274k ohm ±1%, 1/8W	1075-0062	Dale
R4	M Film, 61.9k ohm ±1%, 1/4W	1075-0018	Electra
R5	M Film, 2.43k ohm ±1%, 1/4W	1075-0019	Electra
R6	M Film, 475 ohm ±1%, 1/4W	1075-0023	Electra
R7	M Film, 10k ohm ±1%, 1/4W	1075-0009	Electra
R8	Pot., comp, 100k ohm, 1/2W	1200-0015	Allen-Bradley
R9	M Film, 10k ohm ±1%, 1/4W	1075-0009	Electra
R10	M Film, 5.62k ohm ±1%, 1/4W	1075-0013	Electra
R11	M Film, 5.62k ohm ±1%, 1/4W	1075-0013	Electra
R12	M Film, 10k ohm ±1%, 1/4W	1075-0009	Electra
R13	M Film, 3.4k ohm ±1%, 1/4W	1075-0020	Electra
R14	M Film, 2.43k ohm ±1%, 1/4W	1075-0019	Electra
R15	M Film, 1.43k ohm ±1%, 1/4W	1075-0021	Electra
R16	M Film, 5.62k ohm ±1%, 1/4W	1075-0013	Electra
R17	Pot., comp, 1k ohm 1/2W	1200-0012	Allen-Bradley
R18	M Film, 5.62k ohm ±1%, 1/4W	1075-0013	Electra
R19	M Film, 1.43k ohm ±1%, 1/4W	1075-0021	Electra
R20	M Film, 1k ohm ±1%, 1/2W	1076-0007	Electra

CKT. REF.	DESCRIPTION	C/E STOCK NO.	MFR.
R21	M Film, 5.62k ohm ±1%, 1/4W	1075-0013	Electra
R22	M Film, 5.62k ohm ±1%, 1/4W	1075-0013	Electra
R23	Comp, 1M ohm ±5%, 1/4W	1066-1055	Allen-Bradley
R24	Comp, 470 ohm ±5%, 1/4W	1066-4715	Allen-Bradley
R25	Comp, 330k ohm ±5%, 1/4W	1066-3345	Allen-Bradley
R26	Comp, 47k ohm ±5%, 1/4W	1066-4735	Allen-Bradley
R27	Comp, 4.7k ohm ±5%, 1/4W	1066-4725	Allen-Bradley
R28	Comp, 470 ohm ±5%, 1/4W	1066-4715	Allen-Bradley
R29	M Film, 2.21k ohm ±1%, 1/4W	1075-0010	Electra
R30	M Film, 562 ohm ±1%, 1/2W	1076-0006	Electra
R31	Pot., comp, 10k ohm, 1/2W	1200-0013	Allen-Bradley
R32	Pot., comp, 1k ohm, 1/2W	1200-0012	Allen-Bradley

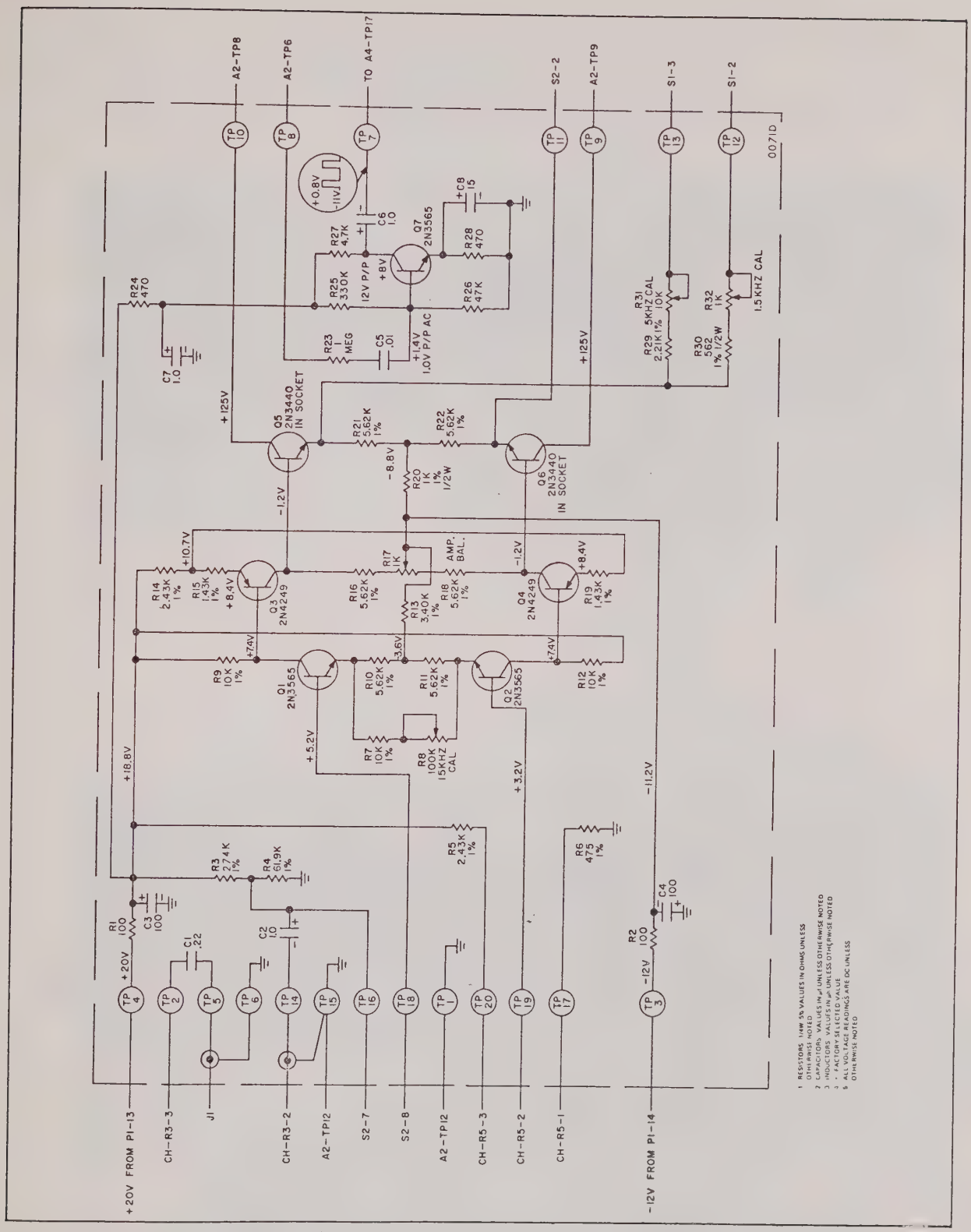
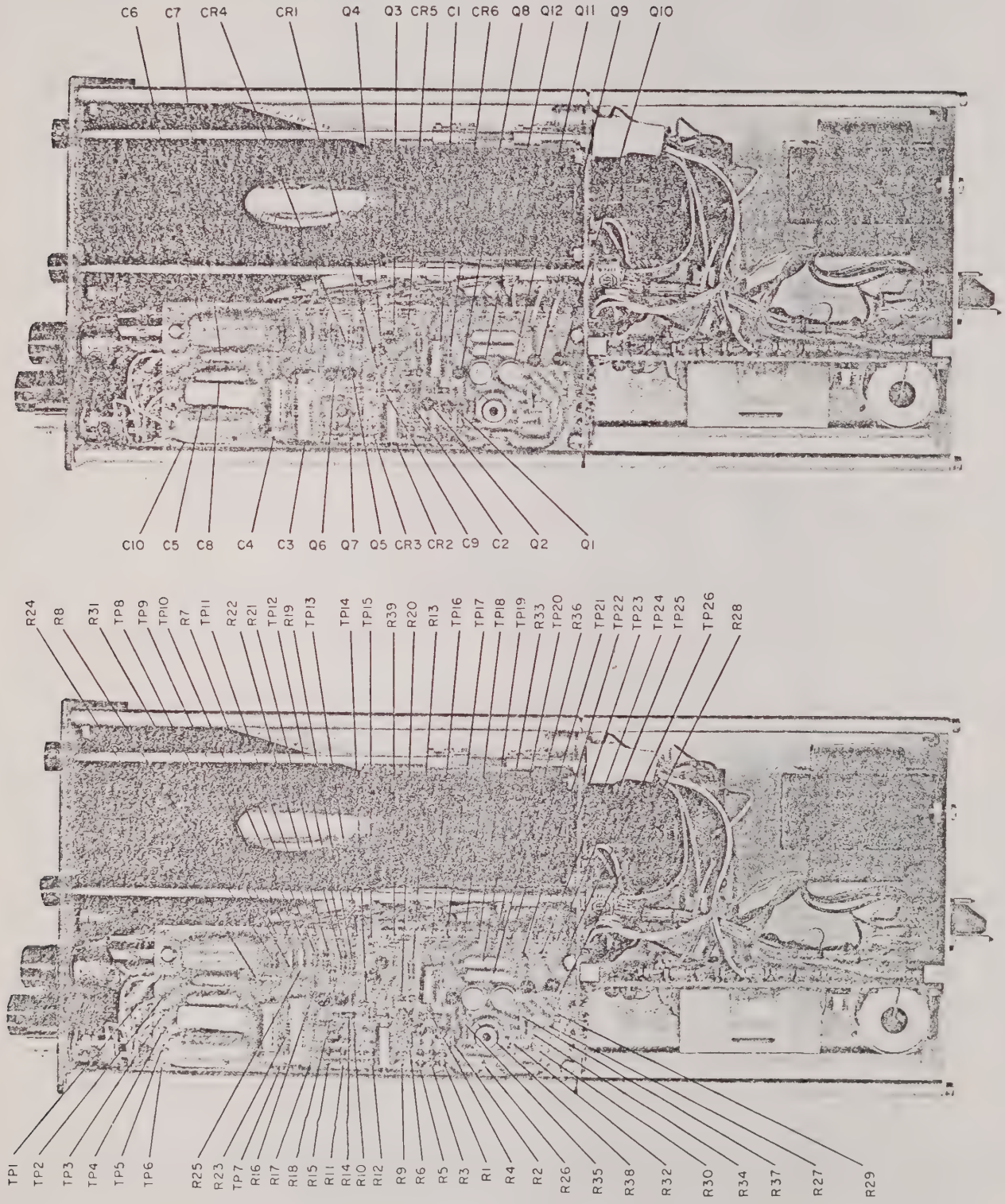


Figure 5.4 Vertical Amplifier, Schematic Diagram

5.2.5 Horizontal Amplifier and Sweep Board



5.2.5 HORIZONTAL AMPLIFIER AND SWEEP BOARD 0072E

CKT. REF.	DESCRIPTION	C/E STOCK NO.	MFR.
	CAPACITORS		
C1	Electro, 1 μF, 25V	1013-0004	Sprague
C2	Mica, 1000 pF ±5%, 100V	1002-0015	Elmenco
C3	Electro, 100 μF, 25V	1013-0003	Sprague
C4	Electro, 100 μF, 12V	1013-0011	Sprague
C5	Metalized Mylar, 1.0 μF ±10%, 100V	1008-0033	TRW
C6	Poly, 0.22 μF ±10%, 400V	1008-0042	Sprague
C7	Poly, 0.039 μF ±10%, 100V	1008-0045	Sprague
C8	Poly, 0.01 μF ±10%, 200V	1008-0043	Sprague
C9	Electro, 15 μF, 25V	1013-0005	Sprague
C10	Poly, 0.22 μF ±10%, 400V	1008-0042	Sprague
	DIODES		
CR1	Si, 1N3064	1281-0013	Sylvania
CR2	Si, 1N3064	1281-0013	Sylvania
CR3	Si, 1N3064	1281-0013	Sylvania
CR4	Si, 1N3064	1281-0013	Sylvania
CR5	Si, 1N3064	1281-0013	Sylvania
CR6	Si, 1N3064	1281-0013	Sylvania
	TRANSISTORS		
Q1	Si, NPN, 2N3565	1272-0017	Fairchild
Q2	Si, NPN, 2N3565	1272-0017	Fairchild
Q3	Si, PNP, 2N4249	1272-0024	Fairchild
Q4	Si, NPN, 2N3565	1272-0017	Fairchild
Q5	Si, NPN, 2N3565	1272-0017	Fairchild
Q6	Si, PNP, 2N4249	1272-0024	Fairchild
Q7	Si, NPN, 2N3565	1272-0017	Fairchild
Q8	Si, PNP, 2N4249	1272-0024	Fairchild
Q9	Si, PNP, 2N4249	1272-0024	Fairchild
Q10	Si, PNP, 2N4249	1272-0024	Fairchild
Q11	Si, NPN, 2N3440	1271-0004	RCA
Q12	Si, NPN, 2N3440	1271-0004	RCA
	RESISTORS		
R1	Comp, 33k ohm ±5%, 1/4W	1066-3335	Allen-Bradley
R2	Comp, 2.2k ohm ±5%, 1/4W	1066-2225	Allen-Bradley
R3	Comp, 22 ohm ±5%, 1/4W	1066-2205	Allen-Bradley
R4	Comp, 3.9k ohm ±5%, 1/4W	1066-3925	Allen-Bradley
R5	Comp, 1k ohm ±5%, 1/4W	1066-1025	Allen-Bradley

CKT. REF.	DESCRIPTION	C/E STOCK NO.	MFR.
R6	Comp, 2.2k ohm ±5%, 1/4W	1066-2225	Allen-Bradley
R7	Comp, 100 ohm ±5%, 1/4W	1066-1015	Allen-Bradley
R8	Comp, 100 ohm ±5%, 1/4W	1066-1015	Allen-Bradley
R9	Comp, 33k ohm ±5%, 1/4W	1066-3335	Allen-Bradley
R10	Comp, 8.2k ohm ±5%, 1/4W	1066-8225	Allen-Bradley
R11	Comp, 12k ohm ±5%, 1/4W	1066-1235	Allen-Bradley
R12	Comp, 33k ohm ±5%, 1/4W	1066-3335	Allen-Bradley
R13	Comp, 4.7k ohm ±5%, 1/4W	1066-4725	Allen-Bradley
R14	Comp, 1k ohm ±5%, 1/4W	1066-1025	Allen-Bradley
R15	Comp, 10k ohm ±5%, 1/4W	1066-1035	Allen-Bradley
R16	Comp, 22k ohm ±5%, 1/4W	1066-2235	Allen-Bradley
R17	Comp, 22k ohm ±5%, 1/4W	1066-2235	Allen-Bradley
R18	Comp, 68k ohm ±5%, 1/4W	1066-6835	Allen-Bradley
R19	Comp, 1.8k ohm ±5%, 1/4W	1066-1825	Allen-Bradley
R20	Comp, 10k ohm ±5%, 1/4W	1066-1035	Allen-Bradley
R21	Comp, 100k ohm ±5%, 1/4W	1066-1045	Allen-Bradley
R22	Comp, 10k ohm ±5%, 1/4W	1066-1035	Allen-Bradley
R23	M Film, 93.1k ohm ±1%, 1/4W	1075-0029	Electra
R24	M Film, 61.9k ohm ±1%, 1/4W	1075-0018	Electra
R25	M Film, 8.45k ohm ±1%, 1/4W	1075-0031	Electra
R26	M Film, 10k ohm ±1%, 1/4W	1075-0009	Electra
R27	M Film, 10k ohm ±1%, 1/4W	1075-0009	Electra
R28	M Film, 3.4k ohm ±1%, 1/4W	1075-0020	Electra
R29	M Film, 3.4k ohm ±1%, 1/4W	1075-0020	Electra
R30	M Film, 10k ohm ±1%, 1/4W	1075-0009	Electra
R31	M Film, 5.62k ohm ±1%, 1/4W	1075-0013	Electra
R32	M Film, 1.43k ohm ±1%, 1/4W	1075-0021	Electra
R33	M Film, 100k ohm ±1%, 1W	1076-0009	Electra
R34	M Film, 2.43k ohm ±1%, 1/4W	1075-0019	Electra
R35	M Film, 2.43k ohm ±1%, 1/4W	1075-0019	Electra
R36	M Film, 100k ohm ±1%, 1W	1076-0009	Electra
R37	M Film, 887 ohm ±1%, 1/4W	1075-0022	Electra
R38	Pot., comp, 10k ohm, 1/2W	1200-0013	Allen-Bradley
R39	Comp, 4.7k ohm ±5%, 1/4W	1066-4725	Allen-Bradley

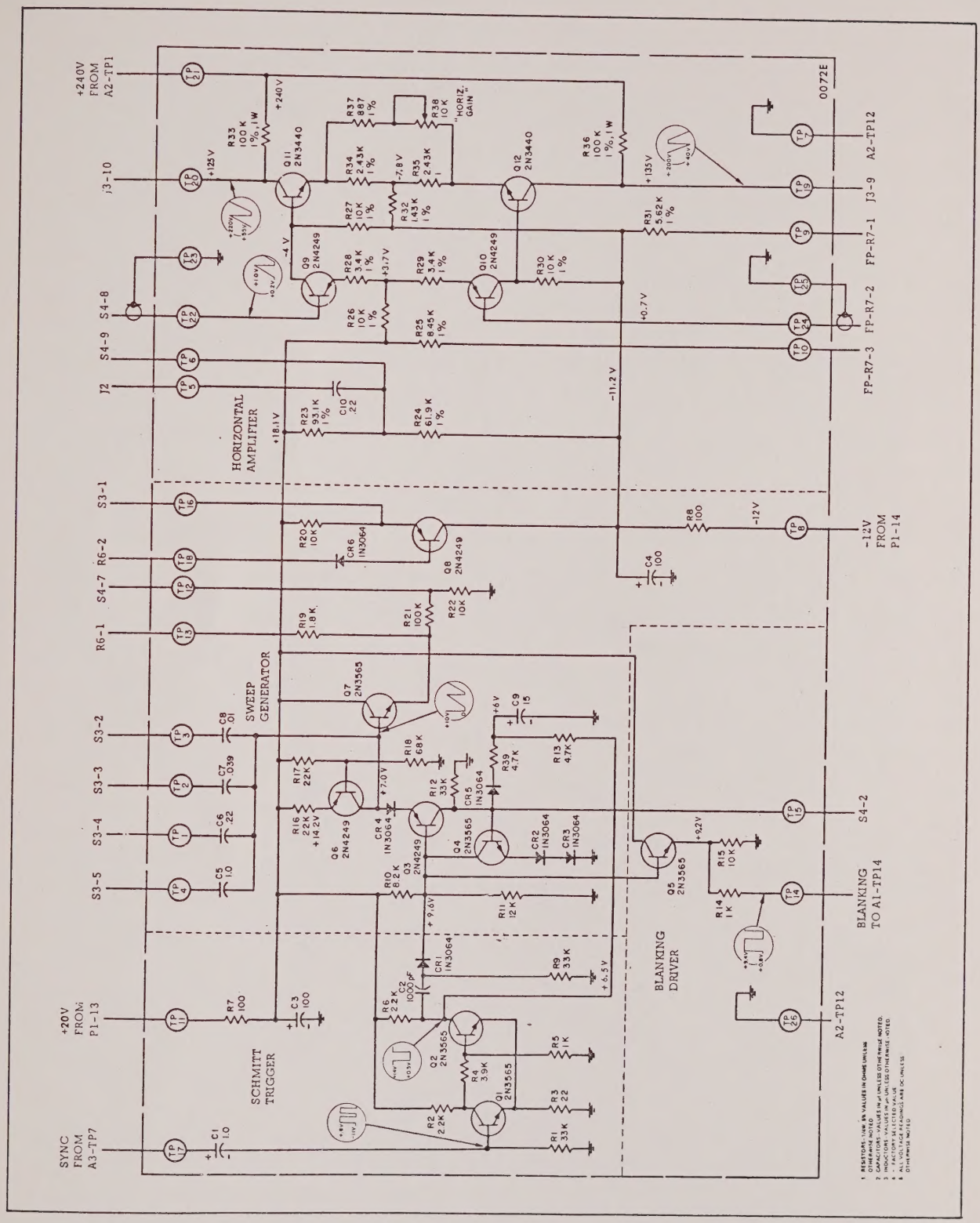


Figure 5.5 Horizontal Amplifier and Sweep Board, Schematic Diagram

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